Multiwavelegth Studies of ULXs in the Chandra Archive of Galaxies

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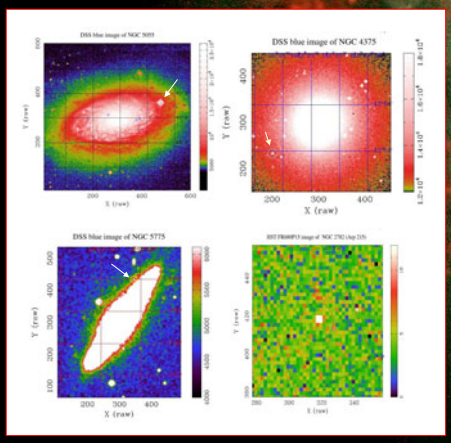
As part of our on-going observational and theoretical study of Ultra-Luminous X-ray sources (ULXs) in the Chandra archive of galaxies, we present results of multiwavelength studies of several ULXs. Long-term X-ray flux and spectral monitoring of these objects have been obtained from archival ROSAT and XMM-Newton observatories. We also report multiwavelength analysis of the environments surrounding these ULXs and our search for counterparts based on archival optical (Hubble, Digitized Sky Survey), UV, and radio data.



Filtering the foreground and background objects from the list of ULX candidates, using DSS/HST data and object catalogues.

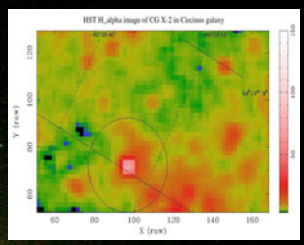
DSS blue images show a foreground star (top left) that coincides with a ULX candidate of NGC 5055 and a background QSO (top right), at redshift z = 1.25, that coincides with a ULX candidate in NGC 4375.

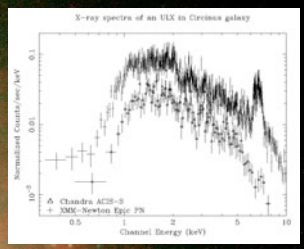
The counterpart of a ULX candidate in NGC 5775 (bottom left) is a 20th magnitude object in the DSS blue image (M_V ~ -11.2 mag assuming the NGC 5775 distance), which may be a bright star cluster. The counterpart of a ULX candidate in NGC 2782 (bottom right) corresponds with a ~25th magnitude blue object in the HST image, which may contain a compact object with a bright accretion disk.

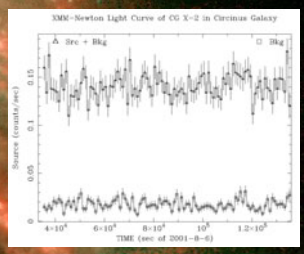
Circinus galaxy X-2

Top right is an HST image of CG X-2, a ULX in the Circinus galaxy, which coincides with an m_V = 22.2 object located in an H_α halo.

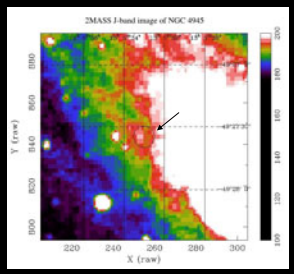
The middle panel shows the XMM-Newton EPIC/PN and Chandra spectra of CG X-2. The higher-sensitivity XMM-Newton spectrum clearly shows the presence of strong Fe K_α and other emission lines. The XMM-Newton EPIC/PN light curve in the bottom panel displays no short-term variations of this source. In the ROSAT HRI observations of the Circinus galaxy between 1995 and 1997, CG X-2 was undetected.

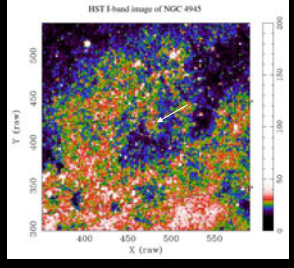






A ULX in NGC 4945





The 2MASS image of NGC 4945 shows an object near the position of the ULX (left, top). This ULX is located in a starforming region and is close to a star cluster. The optical counterpart to the ULX is not clearly detected in the HST image of the galaxy (left, bottom).

The Chandra hard (2.0-8.0 keV) lightcurve of the ULX in NGC 4945 reveals a dip but the soft (0.5-2.0 keV) lightcurve does not show significant short timescale variability. The long term lightcurve (consisting of ROSAT, ASCA, Chandra and XMM-Newton data) shows weak variability. The Chandra and the XMM-Newton EPIC/PN spectra are well fitted by a disk blackbody model. The spectrum is softer during the dip, with kT~ 1 keV, and is harder, kT~1.7 keV, outside the dip (see figure). A peak around 0.1 mHz is present in the power density spectrum